FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY DOCKET NUMBER **LSP-0016**
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) 10/031977
INTERNATIONAL APPLICATION NO. **PCT/EP00/07151**	INTERNATIONAL FILING DATE **26 July 2000**	PRIORITY DATE CLAIMED **29 July 1999**

TITLE OF INVENTION **METHOD FOR POWER OPTIMIZATION IN A VEHICLE/TRAIN HAVING A NUMBER OF DRIVE SYSTEMS**

APPLICANT(S) FOR DO/EO/US **Franke RUDIGER, Peter TERWIESCH, Markus MEYER, Christian KLOSE and Karl-Hermann KETTELER**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. X This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. __ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. X This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. X A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. X A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. __ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. X has been transmitted by the International Bureau.
   c. __ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. X A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. X Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. __ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. __ have been transmitted by the International Bureau.
   c. __ have not been made; however, the time limit for making such amendments has NOT expired.
   d. X have not been made and will not be made.

8. __ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. __ An oath or declaration of the inventor(s) 35 U.S.C. 371(c)(4).

10. __ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. __ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. __ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. __ A FIRST preliminary amendment.
    __ A SECOND or SUBSEQUENT preliminary amendment.

14. __ A substitute specification.

15. __ A change of power of attorney and/or address letter.

16. X Other items or information:
    - **A copy of the Published PCT Application by WIPO under No. WO 01/08958, including the search report.**
    - **A copy of the International Preliminary Examination report, including amended claim 1 under Article 34.**
    - **An English translation of the Response to the Written Opinion.**

EXPRESS MAIL Mailing Label No. **EL 899365920 US**
Date of Deposit: **24 January 2002**

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53 RECEIVED: 23 JAN 2002

U.S. APPLICATION NO. (if known, 37 CFR 1.5) 10/03197	INTERNATIONAL APPLICATION NO. PCT/EP00/07151	ATTORNEY DOCKET NUMBER LSP-0016

17. _ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....**$1,040.00**

International preliminary examination fee (37 CFR 1.482 not paid to USPTO but International Search Report has been prepared by the EPO or JPO.....**$890.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....**$740.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4).....**$710.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4).....**$100.00**

	CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**	
Surcharge of $130.00 for furnishing the oath or declaration later that _ 20 _ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total claims	- 20 =		X $18.00	$	
Independent Claims	- 3 =		x $84.00	$	
Multiple dependent claims(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				**$890.00**	
___ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.				$	
SUBTOTAL =				**$890.00**	
Processing fee of **$130.00** for furnishing the English translation later the _ 20 _30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				**$890.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +					
TOTAL FEES ENCLOSED =				**$890.00**	
				Amount to be: refunded	$
				charged	$

a. X A check in the amount of $ **890.00** to cover the above fee is enclosed.

b. _ Please charge my Deposit Account No. 23-3050 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. _ The Commissioner if hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-3050. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Steven B. Samuels
Woodcock Washburn LLP
One Liberty Place - 46th Floor
Philadelphia, PA 19103
(215) 568-3100

Steven B. Samuels
SIGNATURE

Steven B. Samuels
NAME

37,711
REGISTRATION NUMBER

Method for power optimization in a vehicle/train having a number of drive systems

Description

The invention relates to a method for power optimization in a vehicle/train according to the preamble of claim 1.

During the planning of journeys and the drafting of schedules for rail traffic, time reserves for unforeseen events and adverse operating conditions are included in the plans. Since, during real journeys, the operating conditions are typically more favorable than those assumed during planning, the time reserves created by this are available for other purposes. A particularly practical use of the time reserves resides in the saving of power by means of a suitable travel mode.

Previously known and used methods for power minimization are mostly based on the assumption that a travel mode comprising the constituents maximum acceleration - travel at constant speed - coasting - maximum retardation is optimum in power terms. In this case, the mechanical tractive power which is needed to accelerate the vehicle is minimized. For verification, a linear dynamic train model is used, in particular no account being taken of any term which describes the quadratic relationship between speed and travel resistance.

In DD 255 132 A1, this basic assumption is expanded by subdividing a total route into a number of sections, so that in each section the slope resistance of the journey is constant.

In EP 0 467 377 B1, the subdivision of the overall route into a number of sections is introduced in such a

way that in each section the permissible maximum speed is constant. The travel mode comprising the constituents maximum acceleration - travel at constant speed - maximum retardation is repeated in each section. Coasting is therefore dispensed with.

EP 0 755 840 A1 does not describe a practical method for power optimization but instead explains a general system structure with which power optimization can also be implemented. A cycle comprising acceleration - travel at constant speed - retardation and braking is listed as an example.

The invention is based on the object of specifying an improved method for power optimization with regard to the time reserves included in the planning of a schedule of a vehicle/train.

This object is achieved, in conjunction with the preamble, by the features specified in claim 1.

The advantage that can be achieved with the invention is in particular that, by taking into account the distribution of the drive equipment and multiple traction in the optimization algorithm, instead of the mechanical tractive power the power which is primarily used, such as the electrical power in the case of electric rail vehicles, is minimized.

Advantageous refinements of the invention are identified in the subclaims.

Further advantages of the proposed method emerge from the following description.

The invention will be explained in more detail below using the exemplary embodiments that are illustrated in the drawings and in which:

Fig. 1 shows a characteristic map of the power loss of a typical electric locomotive, and

Fig. 2 shows a characteristic map of the power loss of a typical electric locomotive with two separately controlled drive systems.

The nub of the invention is to be seen in the fact that the distribution of the drive equipment and the multiple traction are taken into account in the optimization problem with regard to the time reserves included in the planning of a schedule of a vehicle/train. Here, the problem of power minimization is formulated as a mathematical optimization problem and solved by a suitable, generally known optimization algorithm.

Suitable optimization algorithms are known, for example, from Papageorgiou: Optimierung [Optimization], Chapters 10, 19 and in particular 20, Oldenbourg Verlag, 1996.

Accordingly, it is assumed that more than one autonomous drive system is available in order to provide the total drive power of a vehicle/train. For example, a typical electric locomotive normally has two bogies, each of which is equipped with separate drives. In addition, designs with three bogies with separate drives are known, as are bogie-less vehicles with two or more driven axles.

In the case of simple traction, in which only one traction vehicle performs the transport, the number of possible separate and autonomous drive systems depends on the circuit topography of the traction vehicle. In the case of electric locomotives, the circuit topography comprises, for example, in addition to the actual drives (motors), primarily further components of the high-voltage equipment and auxiliary equipment, so-

called drive components. In the case of multiple traction, at least two traction vehicles in the composite train are involved in the transport of the train. Likewise, a number of concentrated or distributed drive units can be integrated into one drive train. Here, too, the circuit topography and the number of drive trains coupled in the composite train decide the number of possible separate and autonomous drive systems.

According to the invention, provision is made to take into account a number of completely or partially autonomous drive systems for power minimization with regard to the time reserves included in the planning of a schedule of a vehicle/train, it being possible for each of the drive systems to be characterized using separate functions of efficiency or power loss. When including the distribution of the drive equipment and multiple traction, three procedures are proposed, which can be used individually or in combination.

According to a first procedure, the functions of efficiency or of power loss of the individual autonomous drive systems are combined during preprocessing to form an overall function of the efficiency or the power loss of the vehicle/train. Further optimization is then identical with the optimization for a concentrated system, that is to say a system having only one single autonomous drive system.

According to a second procedure, a representative function (average function) of efficiency or power loss of an autonomous drive system is taken into account in the optimization together with the number of autonomous drive systems respectively used. This procedure is particularly expedient if the efficiency or power loss of the autonomous drive systems do not differ excessively from one another.

According to a third procedure, for each autonomous drive system, a function of efficiency or power loss and the binary state information ON or OFF (that is to say the actions of switching the individual autonomous drive systems on/off) are taken into account in the optimization. This procedure is particularly expedient if the efficiency or power loss of the autonomous drive systems are different to a greater extent.

While, in the case of the third procedure, there is already a plan of use for each individual autonomous drive system in the result of the optimization, in the case of the first two procedures, this has to be drawn up further through post-processing.

By taking into account the distribution of autonomous drive systems, the optimum combination of the individual drives can be determined for each traveling situation and set in a predictive way. At the same time, boundary conditions, such as the tractive and braking forces to be expected, adhesion coefficient, temperatures in the drive components and time influences in the drive dynamics, are taken into account. Furthermore, switching-on and switching-off losses can be minimized, whilst simultaneously taking into account the further losses of the vehicle.

Fig. 1 shows a characteristic map of the power loss as a function of the tractive force and the speed of a drive system of a typical electric locomotive.

Fig. 2 shows a characteristic map, put together to accord with the first procedure, of the power loss (overall function) as a function of the tractive force and the speed of a typical electric locomotive, including switching off an autonomous drive system of a bogie in the lower output range.

Patent Claims

1. A method for power optimization in a vehicle/train, using time reserves which are included when planning a schedule, wherein in order to achieve a power-saving travel mode with the aid of an optimization algorithm, the presence of a number of completely or partially autonomous drive systems is taken into account, the separate functions of efficiency or power loss of each drive system being taken into consideration.

2. The method as claimed in claim 1, wherein the separate functions of efficiency or power loss of the individual drive systems are combined during preprocessing to form an overall function of the efficiency or power loss of the vehicle/train.

3. The method as claimed in claim 1, wherein the separate functions of efficiency or power loss of the individual drive systems are combined to form a representative function of the efficiency or power loss of the drive system and are taken into account together with the number of autonomous drive systems currently used.

4. The method as claimed in claim 1, wherein, for each drive system, a separate function of efficiency or power loss, and the binary state information ON or OFF of each drive system, are taken into account.

5. The method as claimed in one of claims 1 to 4, wherein when autonomous drive systems are being selected, boundary conditions such as tractive and braking forces to be expected and/or adhesion coefficients and/or temperature and/or influences in the drive dynamics are taken into account.

Method for power optimization in a vehicle/train having a number of drive systems

Abstract

A method for power optimization in a vehicle/train, using time reserves which are included when planning a schedule, is proposed. In order to achieve a power-saving travel mode with the aid of an optimization algorithm, the presence of a number of completely or partially autonomous drive systems is taken into account, the separate functions of efficiency or power loss of each drive system being taken into consideration.

Relevant figure: Fig. 1

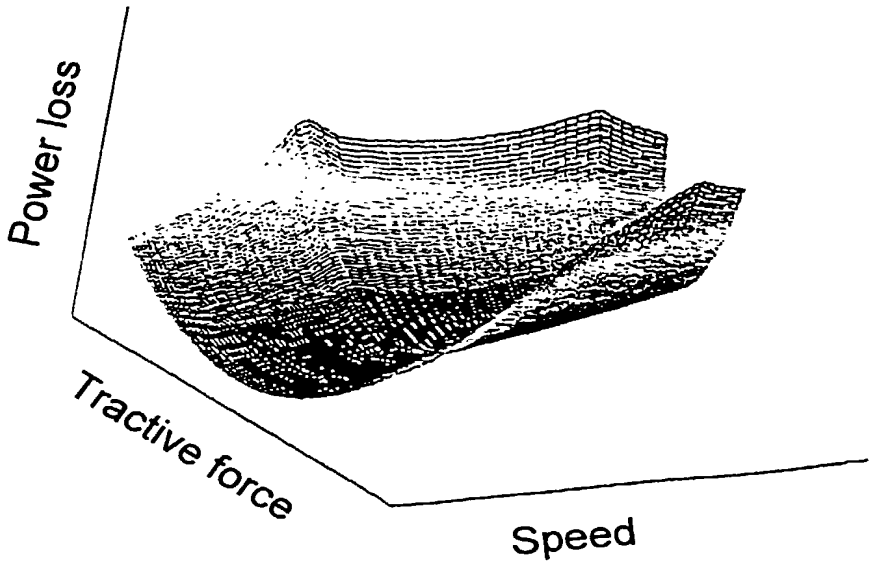

Figure 1

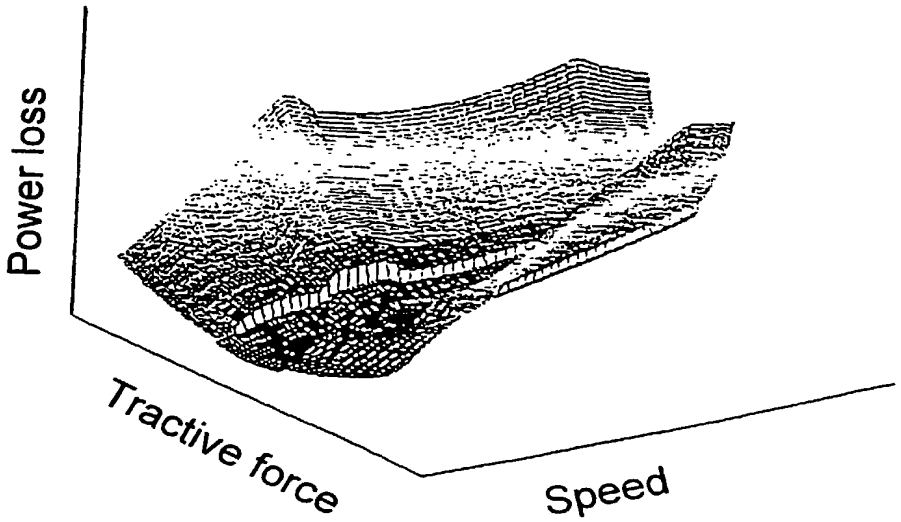

Figure 2

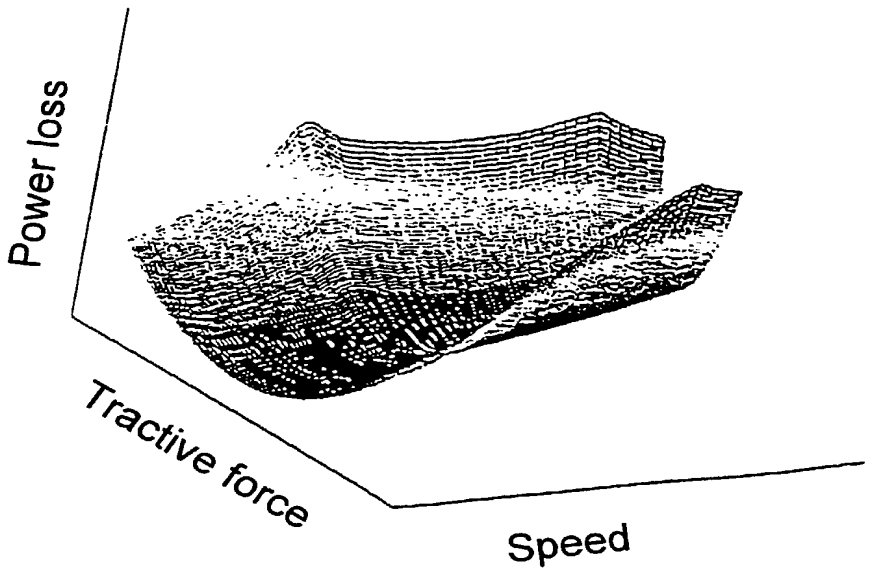

Figure 1

Abstract

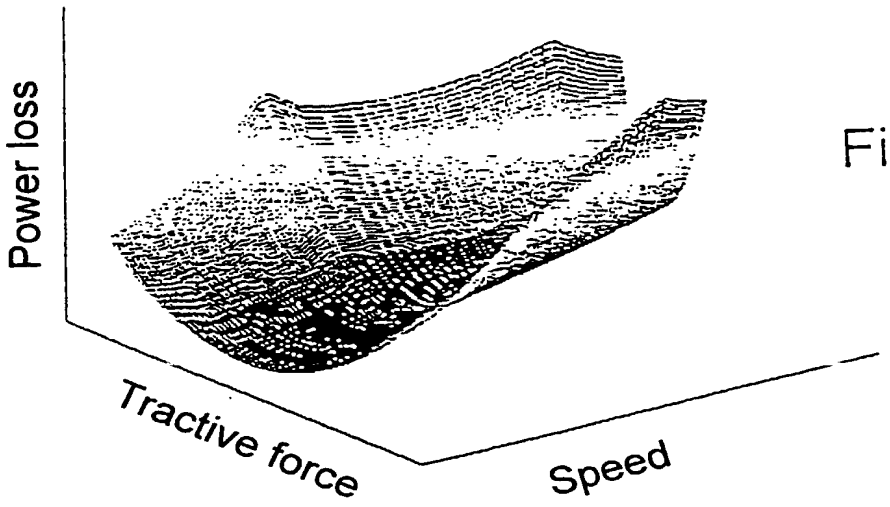

Fig. 1

Abstract

PTO/SB/103 (8-96) (modified)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Declaration and Power of Attorney for Patent Application
Erklärung für Patentanmeldungen mit Vollmacht

German Language Declaration

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As a below named inventor, I hereby declare that:

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My residence, post office address and citizenship are as stated next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Falle Zutreffendes bitte ankreuzen), diese Erfindung

the specification of which is attached hereto unless the following box is checked:

☒ wurde angemeldet am / was filed on: **26 July 2000**

unter der US-Anmeldenummer oder unter der Internationalen Anmeldenummer im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) /
as United States Application Number or PCT International Application Number: **PCT/EP00/07151**

und am / and was amended on (if applicable) **21 June 2001** abgeändert (falls zutreffend).

Ich bestätige hiermit, daß ich den Inhalt der oben angegebenen Patentanmeldung, einschließlich der Ansprüche, die eventuell durch einen oben erwähnten Zusatzantrag abgeändert wurde, durchgesehen und verstanden habe.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Code of Federal Regulations, § 1.56 von Belang sind.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäß Title 35, United States Code, § US-Code, § 119 (a)-(d), bzw. § 365(b) aller unten aufgeführten Auslandsanmeldungen für Patente oder Erfinderurkunden, oder § 365(a) aller PCT internationalen Anmeldungen, welche wenigstens ein Land ausser den Vereinigten Staaten von Amerika benennen, und habe nachstehend durch ankreuzen sämtliche Auslands-anmeldungen für Patente bzw. Erfinderurkunden oder PCT internationale Anmeldungen angegeben, deren Anmeldetag dem der Anmeldung, für welche Priorität beansprucht wird, vorangeht.

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Prior Foreign Applications / Frühere ausländische Anmeldungen

(Number) (Nummer)	(Country) (Land)	(Filing Date: day/month/year) (Anmeldetag : tag/monat/jahr)	Priority Not Claimed Priorität nicht beansprucht
19935353.0	**Germany**	**29 July 1999**	☐
PCT/EP00/07151	**PCT**	**26 July 2000**	☐

Ich beanspruche hiermit Prioritätsvorteile unter Title 35, US-Code, § 119(c) aller US-Hilfsanmeldungen wie unten aufgezählt.

I hereby claim the benefit under Title 35, United States Code, § 119(c) of any United States provisional application(s) listed below.

(Application No.) (Aktenzeichen)	(Filing Date: day/month/year) (Anmeldetag : tag/monat/jahr)

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(Application No.) (Aktenzeichen)	(Filing Date: day/month/year) (Anmeldetag : tag/monat/jahr)	(Status) (patented, pending, abandoned) (Status) (patentiert, schwebend, aufgegeben)

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39

Jason C. Abair, Reg. No. 44,007; Michael J. Bell, Reg. No. 39,604; Stephen H. Cagle, Reg. No. 26,445; Celine T. Callahan, Reg. No. 34,301; Jenny W. Chen, Reg. No. 44,604; Mary S. Consalvi, Reg. No. 32,212; Thomas E. Coverstone, Reg. No. 36,492; Ben M. Davidson, Reg. No. 38,424; James F. Davis, Reg. No. 21,072; Thomas M. Dunham, Reg. No. 39,963; Alan M. Grimaldi, Reg. No. 26,599; J. Jay Guiliano, Reg. No. 41,810; Albert P. Halluin, Reg. No. 25,227; Derek J. Jardieu, Reg. No. 44,483; Patricia A. Kammerer, Reg. No. 29,775; Christopher L. Kelley, Reg. No. 42,714; John R. Keville, Reg. No. 42,723; Brian S.Y. Kim, Reg. No. 41,114; Viola T. Kung, Reg. No. 41,131; Robert C. Laurenson, Reg. No. 34,206; Joseph P. Lavelle, Reg. No. 31,036; Don F. Livornese, Reg. No. 32,040; Craig M. Lundell, Reg. No. 30,284; Christopher A. Mathews, Reg. No. 35,944; Matthew J. Moore, Reg. No. 42,012; David P. Owen, Reg. No. 43,344; Andrew Y. Piatnicia, Reg. No. 40,772; Jacobus C. Rasser, Reg. No. 37,043; Glenn W. Rhodes, Reg. No. 31,790; Michael J. Stimson, Reg. No. 45,429; Janelle D. Waack, Reg. No. 36,300; William K. West, Reg. No. 22,057; Carter J. White, Reg. No. 41,374; Adam K. Whiting, Reg. No. 44,400; Jayna R. Whitt, Reg. No. 47,175; Karen K. Wong, Reg. No. 44,409; Wallace Wu, Reg. No. 45,380; Matthew S. Zises, Reg. No. 47,246; each an attorney or agent with the law firm of Howrey Simon Arnold & White, and all other practitioners associated with Howrey Simon Arnold & White, as its attorney or agent so long as they remain with such law firm.

Postanschrift / Send Correspondence to:

David P. Owen
Howrey Simon Arnold & White
CityPoint, One Ropemaker Street
London EC2Y 9HS, England

Telefonische Auskünfte: *(Name und Telefonnummer)* / Direct Telephone Calls to: *(name and telephone number)*

David P. Owen
011 44 20 7628 3303 (please note: this is a telephone number is in London, England)

1-0D

Vor- und Zuname des einzigen oder ersten Erfinders/Full name of sole or first inventor: **RUDIGER FRANKE**
Unterschrift des einzigen oder ersten Erfinders / Inventor's signature: Date: 16.7.2002 Datum /
Wohnsitz / Residence: Fritz-Frey-Strasse 2 D-69121, Heidelberg, Germany DEX
Staatsangehörigkeit / Citizenship: DE
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des zweiten Erfinders (falls zutreffend) / Full name of second joint inventor, if any: **PETER TERWIESCH**
Unterschrift des zweiten Erfinders / Second inventor's signature: Datum / Date:
Wohnsitz / Residence: Gartenweg 459, CH-5512 Wohlenschwiel, Switzerland
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

Jason C. Abair, Reg. No. 44,007; Michael J. Bell, Reg. No. 39,604; Stephen H. Cagle, Reg. No. 26,445; Celine T. Callahan, Reg. No. 34,301; Jenny W. Chen, Reg. No. 44,604; Mary S. Consalvi, Reg. No. 32,212; Thomas E. Coverstone, Reg. No. 36,492; Ben M. Davidson, Reg. No. 38,424; James F Davis, Reg. No. 21,072; Thomas M. Dunham, Reg. No. 39,965; Alan M. Grimaldi, Reg. No. 26,599; J. Jay Guiliano, Reg. No. 41,810; Albert P. Halluin, Reg. No. 25,227; Derek J. Jardieu, Reg. No. 44,483; Patricia A. Kammerer, Reg. No. 29,775; Christopher L. Kelley, Reg. No. 42,714; John R. Keville, Reg. No. 42,723; Brian S.Y. Kim, Reg. No. 41,114; Viola T. Kung, Reg. No. 41,131; Robert C. Laurenson, Reg. No. 34,206; Joseph P. Lavelle, Reg. No. 31,036; Don F. Livornese, Reg. No. 32,040; Craig M. Lundell, Reg. No. 30,284; Christopher A. Mathews, Reg. No. 35,944; Matthew J. Moore, Reg. No. 42,012; David P. Owen, Reg. No. 43,344; Andrew Y. Piatmicia, Reg. No. 40,772; Jacobus C. Rasser, Reg. No. 37,043; Glenn W. Rhodes. Reg. No. 31,790; Michael J. Stimson, Reg. No. 45,429; Janelle D. Waack, Reg. No. 36,300; William K. West, Reg. No. 22,057; Carter J. White, Reg. No. 41,374; Adam K. Whiting, Reg. No. 44,400; Jayna R. Whitt, Reg. No. 47,175; Karen K. Wong, Reg. No. 44,409; Wallace Wu, Reg. No. 45,380; Matthew S. Zises, Reg. No. 47,246; each an attorney or agent with the law firm of Howrey Simon Arnold & White, and all other practitioners associated with Howrey Simon Arnold & White, as its attorney or agent so long as they remain with such law firm.

Postanschrift / Send Correspondence to:

David P. Owen
Howrey Simon Arnold & White
CityPoint, One Ropemaker Street
London EC2Y 9HS, England

Telefonische Auskünfte: (*Name und Telefonnummer*) / Direct Telephone Calls to: (*name and telephone number*)

David P. Owen
011 44 20 7628 3303 (please note: this is a telephone number is in London, England)

Vor- und Zuname des einzigen oder ersten Erfinders/Full name of sole or first inventor: **RUDIGER FRANKE**
Unterschrift des einzigen oder ersten Erfinders / Inventor's signature: Datum / Date:
Wohnsitz / Residence: Fritz-Frey-Strasse, 2 D-69121, Heidelberg, Germany
Staatsangehörigkeit / Citizenship: DE
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des zweiten Erfinders (falls zutreffend) / Full name of second joint inventor, if any: **PETER TERWIESCH**
Unterschrift des zweiten Erfinders / Second inventor's signature: P. Terwiesch Datum / Date: 2002-06-12
Wohnsitz / Residence: Gartenweg ~~459~~ 19, ~~CH-5512 Wohlenschwil~~, Switzerland CHX
Staatsangehörigkeit / Citizenship: ~~CH~~ DE
Postanschrift / Post Office Address: Same as above

Vor- und Zuname des dritten Erfinders (falls zutreffend) / Full name of third joint inventor, if any: **MARKUS MEYER**
Unterschrift des dritten Erfinders / Third Inventor's signature: M. Meyer Datum / Date: 7.6.2002
Wohnsitz / Residence: Hochweidstrasse 7, CH-6030 Ebikon, Switzerland CH
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des vierten Erfinders (falls zutreffend) / Full name of fourth joint inventor, if any: **CHRISTIAN KLOSE**
Unterschrift des vierten Erfinders / Fourth inventor's signature: Datum / Date:
Wohnsitz / Residence: Starweg 28, D-14771 Brandenburg a.d. Havel, Germany
Staatsangehörigkeit / Citizenship: DE
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des fünften Erfinders (falls zutreffend) / Full name of fifth joint inventor, if any: **KARL-HERMANN KETTELER**
Unterschrift des fünften Erfinders / Fifth Inventor's signature: Datum / Date:
Wohnsitz / Residence: Schwachelerstrasse 29, CH-5314 Kleindoltingen, Switzerland
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above

Vor- und Zuname des dritten Erfinders (falls zutreffend) / Full name of third joint inventor, if any: **MARKUS MEYER**
Unterschrift des dritten Erfinders / Third Inventor's signature: Datum / Date:
Wohnsitz / Residence: Hochweidstrasse 7, CH-6030 Ebikon, Switzerland
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des vierten Erfinders (falls zutreffend) / Full name of fourth joint inventor, if any: **CHRISTIAN KLOSE**
Unterschrift des vierten Erfinders / Fourth inventor's signature: Datum / Date: 16.08.02
Wohnsitz / Residence: ~~Starweg 28, D-14771 Brandenburg a.d. Havel,~~ Germany Hauptstraße 46 D-14789 Glienicke
Staatsangehörigkeit / Citizenship: DE DEX
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des fünften Erfinders (falls zutreffend) / Full name of fifth joint inventor, if any: **KARL-HERMANN KETTELER**
Unterschrift des fünften Erfinders / Fifth Inventor's signature: Datum / Date:
Wohnsitz / Residence: Schwachelerstrasse 29, CH-5314 Kleindoltingen, Switzerland
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above

Vor- und Zuname des dritten Erfinders (falls zutreffend) / Full name of third joint inventor, if any: **MARKUS MEYER**
Unterschrift des dritten Erfinders / Third Inventor's signature: Datum / Date:
Wohnsitz / Residence: Hochweidstrasse 7, CH-6030 Ebikon, Switzerland
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des vierten Erfinders (falls zutreffend) / Full name of fourth joint inventor, if any: **CHRISTIAN KLOSE**
Unterschrift des vierten Erfinders / Fourth inventor's signature: Datum / Date:
Wohnsitz / Residence: Starweg 28, D-14771 Brandenburg a.d. Havel, Germany
Staatsangehörigkeit / Citizenship: DE
Postanschrift / Post Office Address: Same as above
Vor- und Zuname des fünften Erfinders (falls zutreffend) / Full name of fifth joint inventor, if any: **KARL-HERMANN KETTELER**
Unterschrift des fünften Erfinders / Fifth Inventor's signature: K-H Ketteler Datum / Date: 8.6.2002
Wohnsitz / Residence: Schwachelerstrasse 29, ~~CH-5314 Kleindeltingen~~ ad Hinrey, Switzerland CH
Staatsangehörigkeit / Citizenship: CH
Postanschrift / Post Office Address: Same as above